
Chapter 5

Coordinate Geometry

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5.1 Objectives

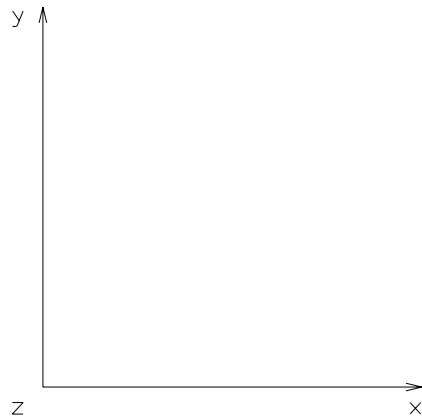
- Learn to set up and access the coordinate geometry database.
- Become proficient in using Geopak Coordinate Geometry.

5.2 Definitions

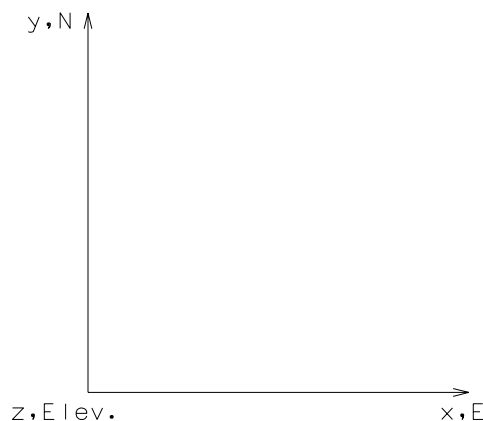
Coordinate Geometry (COGO) is a method of using XYZ coordinates to store geometric elements such as points, lines, curves, spirals, chains, parcels, and profiles. The **Coordinate Geometry** dialog box is an interactive graphical user interface for storing coordinate geometry elements.

5.2.1 Coordinate System

The coordinate system is defined with **XYZ** coordinates. The **X** and **Y** coordinates define a horizontal plane, while the **Z** coordinate defines the vertical dimension. All points in a cogo element are defined by at least an **X** coordinate and a **Y** coordinate. If an elevation is to be stored, the **Z** coordinate will also be defined.



The **XYZ** coordinates can also be referred to in **Northing (N)**, **Easting (E)**, and **Elevation (Z)** coordinates. The **Northing** coordinate refers to the **Y** value, the **Easting** coordinate refers to the **X** value, and the **Elevation** refers to the **Z** value.



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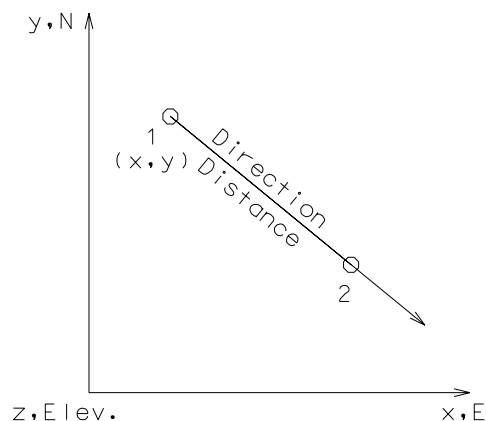
The user must be aware of the coordinate system the data is in, and the coordinate system that GEOPAK is using. When referring to the **XYZ** coordinate system, the coordinates are listed as **(X, Y, Z)**. When referring to the **Northing, Easting, Elevation** coordinate system, the coordinates are listed as **(N, E, Elev.)**. When translating this to the **XYZ** coordinate system, the coordinates would be **(Y, X, Z)**.

5.2.2 Points

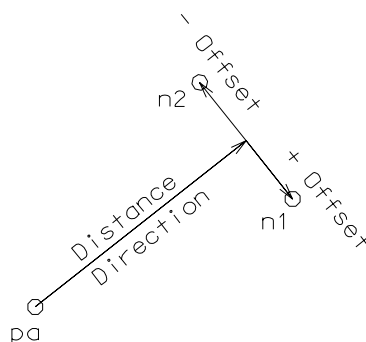
Points are defined by a single set of coordinates. Each **point** will have an X and a Y coordinate. The point may also have a Z coordinate if an elevation is defined.

Point names are alpha-numeric. If alphabetic characters are used, they must come before any numeric characters. The **point** name must contain at least 1 numeric character at the end of the name. Names can be up to 9 characters in length, although limiting the name to 8 characters is recommended.

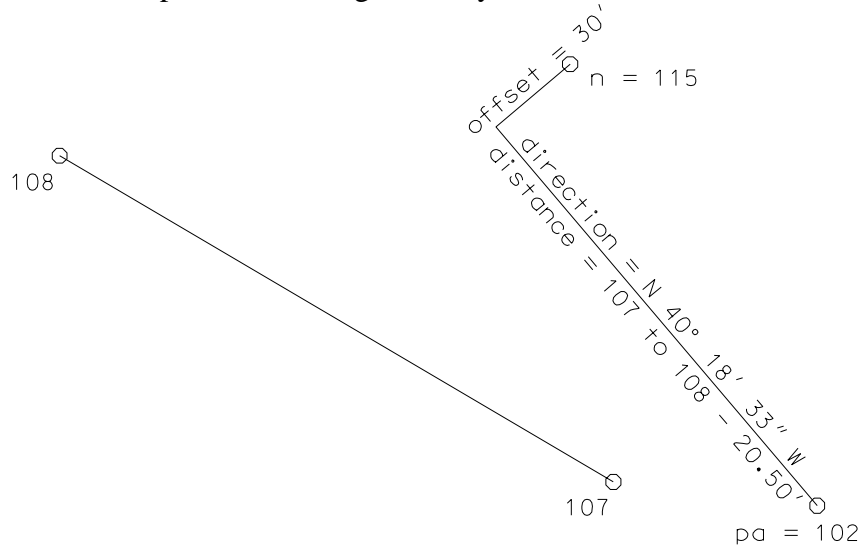
Points can be stored from a set of coordinates, or located from other elements. To define a point from another point, a distance and direction need to be defined.



Modifiers can be added to the direction and distance. An offset can be applied. This will locate the point at the specified distance and direction from the starting point, then perpendicular to the specified direction for the specified offset distance. A positive offset will go to the right of the specified direction, and a negative offset will go to the left of the specified direction.



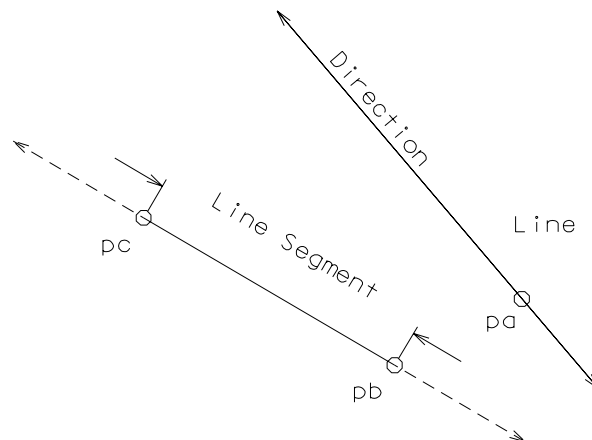
Distances and directions can also be found mathematically. Values can be added, subtracted, multiplied, divided, or computed with a trigonometry function



loc 115 trav 102 dis 107 to 108 m 20.50 n 40 18 33 w off 30

5.2.3 Lines and Line Segments

Lines are defined by a location point and a direction, and are infinite in length. **Line Segments** are a portion of a line that is defined by a beginning and an ending point. **Line Segment** names can be alpha-numeric up to nine characters, but cannot be numeric-alpha.



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5.2.4 Curves

Curves are a segment of a circular arc. **Curves** can be defined by either the **arc method** (central angle that produces a 100' arc) or **chord definition** (central angle that produces a 100' chord). MoDOT uses the arc definition for all new alignments, however the chord definition has been used in the past, and may still be shown on old plans.

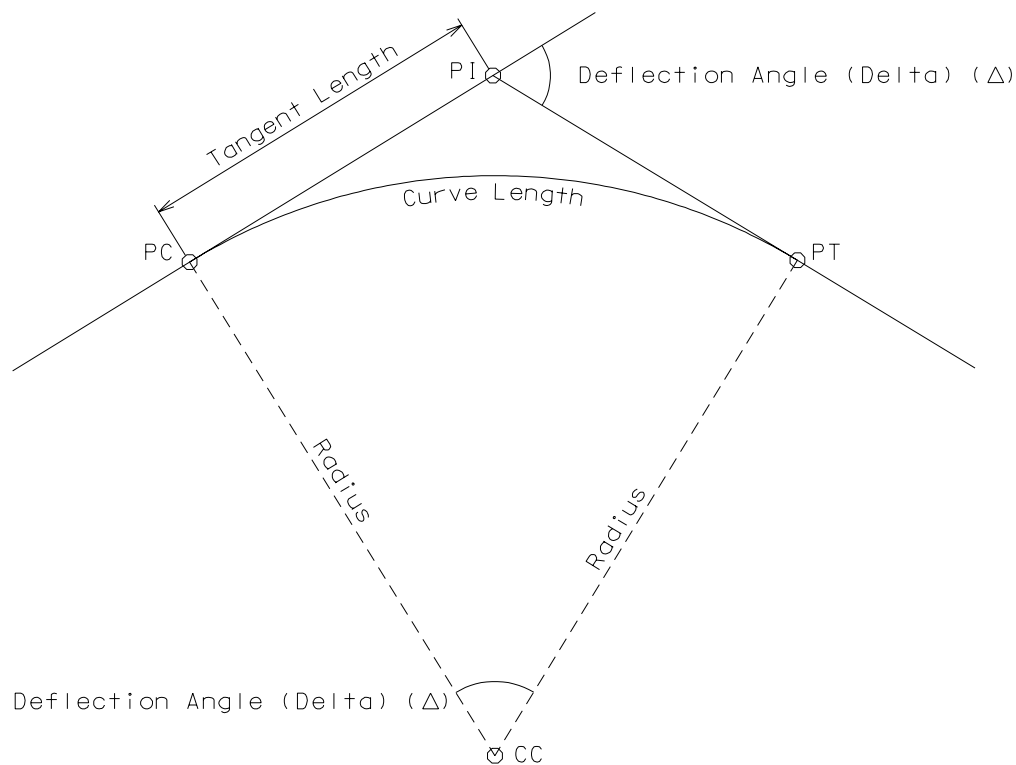
A **curve** has several points associated with it. These points help to define the **curve**, and are stored automatically when the **curve** is stored.

PC – Point of Curvature; Beginning of the curve.

PT – Point of Tangency; End of the curve.

PI – Point of Intersection; Point where the two tangents meet.

CC – Circle Center; Point at the center of the circle from which the curve is segmented.



Curve names can be any alpha-numeric characters up to nine characters in length.

5.2.5 Spirals

Spirals are a transitional curve. Typically a **spiral** will transition from a tangent (infinite radius) to a specified radius defined by a curve. **Spirals** can also transition between 2 specified radii as defined by 2 curves.

Several points are also stored with a **spiral**. They are as follows:

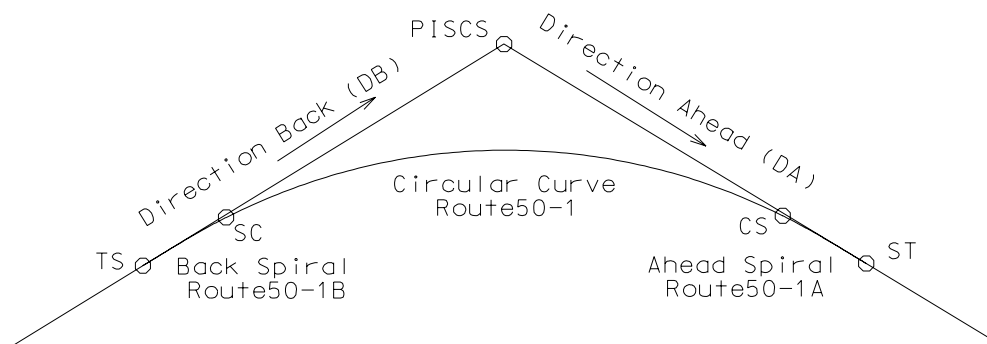
TS – Tangent to Spiral Point

SC – Spiral to Curve Point

CS – Curve to Spiral Point

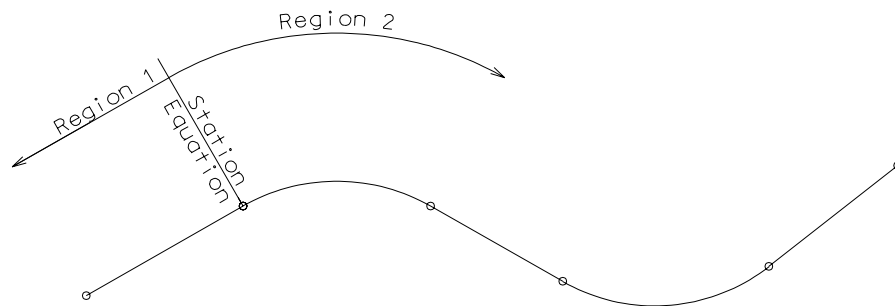
ST – Spiral to Tangent Point

PISCS – Overall Point of Intersection for the spiral-curve-spiral combination.



5.2.6 Chains

Chains are a combination of other elements. They can consist of points, curves, spirals, or other chains. **Chains** can represent horizontal alignments, or the horizontal location of some element. **Chains** have **stationing** associated with them. Locations along the chain can be determined by the **stationing**. If the **stationing** is adjusted along the **chain** a **station equation** is used. The **stations** from the beginning of the **chain** to the first **station equation** are referred to as Region 1. The **stations** from the first **station equation** to the second **station equation** or the end of the **chain** are referred to as Region 2.



Chain names can be any alpha-numeric characters up to a length of nine characters.

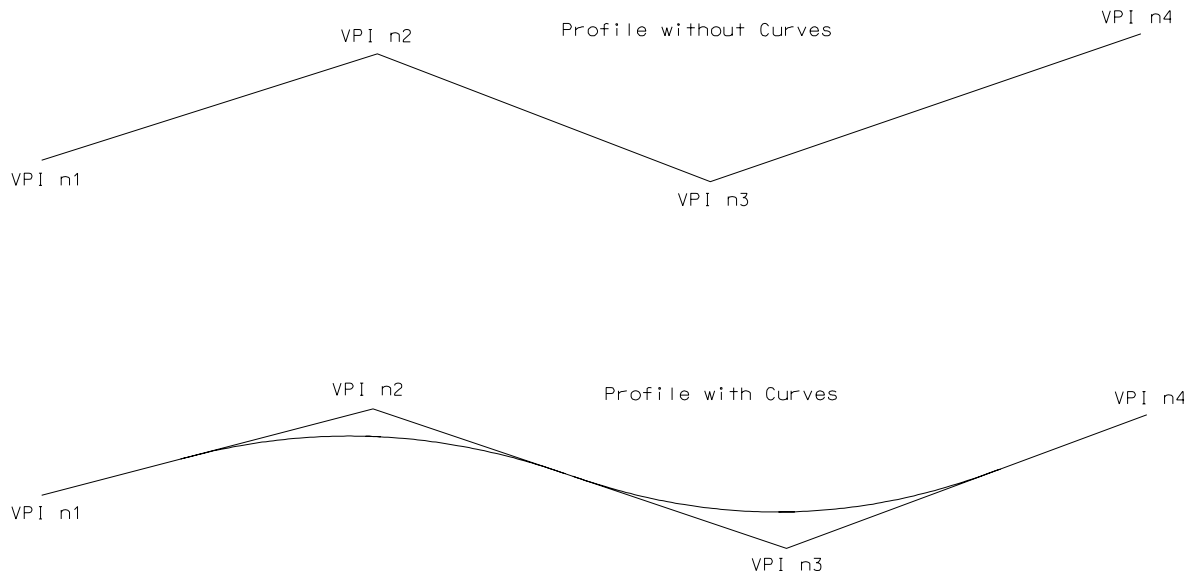
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5.2.7 Profiles

Profiles are vertical alignments defined by stations and elevations. They are generally associated with some horizontal chain. **Profiles** can be stored with or without vertical curves.

Profiles without curves generally represent the existing ground profile, or a ditch profile.

Profiles with vertical curves are generally used as proposed alignment profiles.



5.3 Accessing



From **Project Manager** choose **Coordinate Geometry**, or choose the **Coordinate Geometry** icon.

The screenshot shows a dialog box titled 'GEOPAK Coordinate Geometry'. It contains four input fields: 'Project Name', 'Job Number', 'Operator Code', and 'Subject'. The 'Job Number' field has a 'Select' button next to it. At the bottom are 'OK' and 'Cancel' buttons.

When Coordinate Geometry is started, the **Start-Up Dialog Box** appears.

Project Name – shows name displayed on reports (optional entry, 60 alphanumeric characters max). If **Project Manager** is used, this field will be filled in automatically.

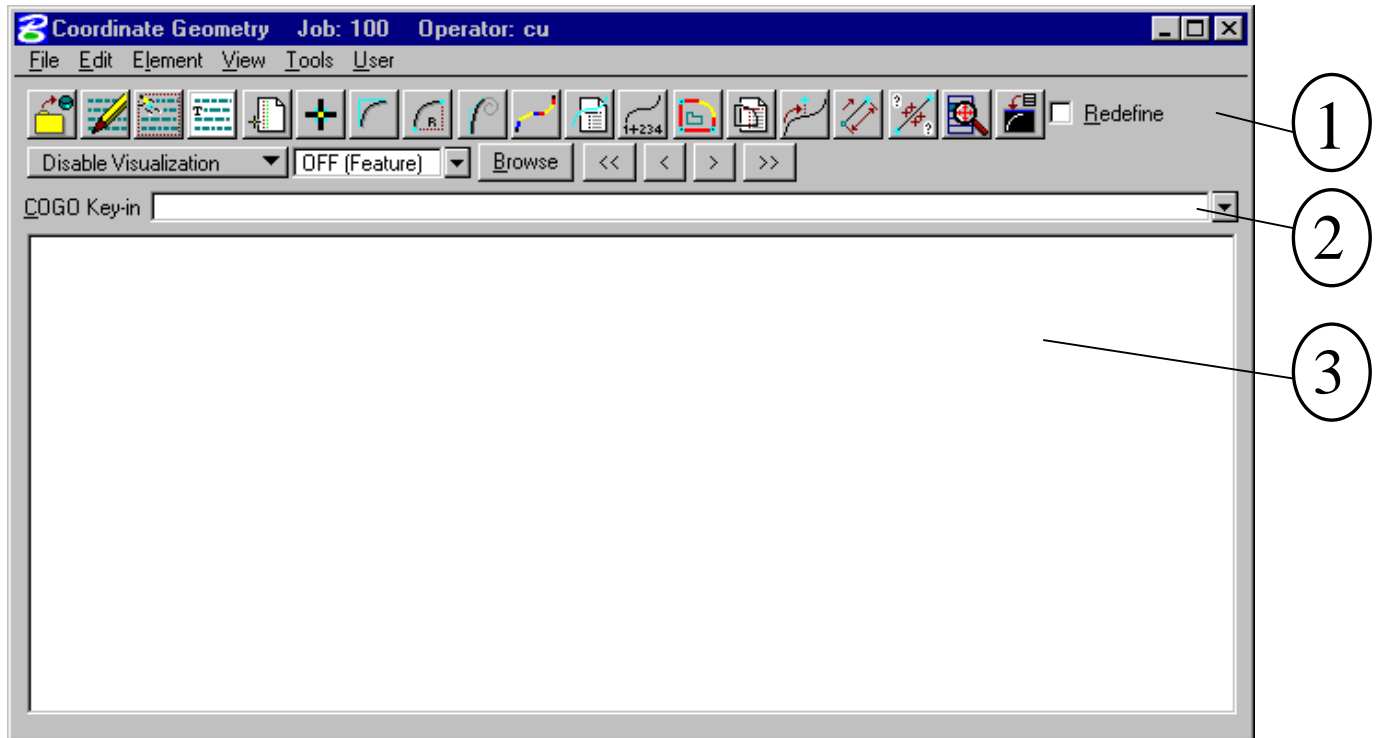
Job Number - identifies coordinate geometry database (3 alphanumeric characters, max) (required). If **Project Manager** is used, this field will be filled in automatically.

Operator Code – identifies a unique 2-character operator code. Allows multiple users access to database. (Required, user's initials suggested). If **Project Manager** is used, this field will be filled in automatically.

Subject - description of work (48 alphanumeric characters, max) (optional)

Once these parameters have been defined, the coordinate geometry dialog box will appear.

5.4 Coordinate Geometry Dialog Box

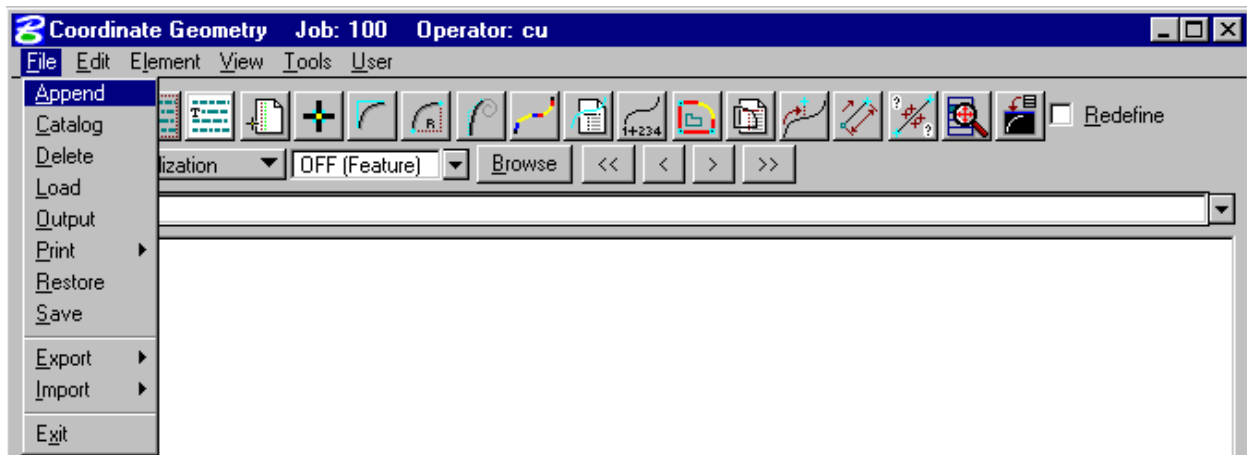


The coordinate geometry dialog box is made up of three separate display areas:

- 1) **Tool Bar** consisting of pull down menus and icons. The icons displayed are customizable.
- 2) **Command Key-in** allows commands to be typed in. The drop down button allows for a history of commands to be seen.
- 3) **Output Window** shows the results generated by the commands.

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5.4.1 File Commands



Append - this command is for *input files* only. A new input file is created by copying the contents of an existing input file to the end of the current input file; you must use the **Save** command to store this new file.

Catalog - when selected, a menu appears listing all saved input files in the project directory. This is for reference only no action is taken.

Delete - when selected, a menu appears listing all saved input files. *Highlight* a file then click the **OK** button to remove this file from your project directory.

Load - when selected, a menu appears listing all saved input files. *Highlight* a file then click the **OK** button. The input lines from the highlighted file are now displayed in the output buffer and are ready for modify, delete, edit or read.

Output - writes a Geopak output file from your current output buffer session to a newly created file for reviewing and printing. (**Fname999.ooc**)

Print - sends your output/input file to the printer.

Restore – converts an ASCII file of Geopak commands to a Geopak COGO input file.

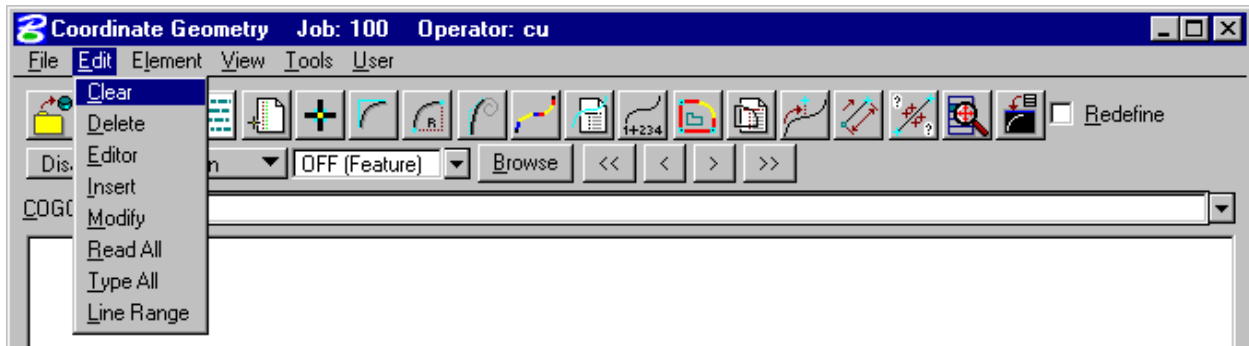
Save - will save the current input buffer to a file. (**Fname999.ioc**)

Export - will export Geopak chains and profiles into RDS format and Geopak chains and points into SDMS format.

Import - will import horizontal and vertical alignments and points from RDS and SDMS format into the Geopak .gpk file.

Exit - closes the COGO dialog box and ends the coordinate geometry session. A prompt to save the session appears. **Yes** saves the input buffer, **No** exits without saving, **Cancel** returns to the COGO session. Whether you pick **Yes** or **No** everything you did is still saved in the .gpk file.

5.4.2 Edit Commands



Clear - empties the memory of the current input and output buffers without saving and initializes the line numbers to begin a new sequence of commands.

Delete - deletes input commands in the input buffer by line number (or range of line numbers) and re-sequences the line numbers for the remaining commands.

Editor - opens the **Geopak COGO Command Editor**, which allows the user to edit an input file before executing.

Insert - allows the user to add a command line to the current input buffer *before* a specified line number; the other command lines will shift down and line numbering will automatically be re-sequenced

Modify - allows the user to change a word in a command line. The modified command line will not be computed until the operator uses the **Read** command.

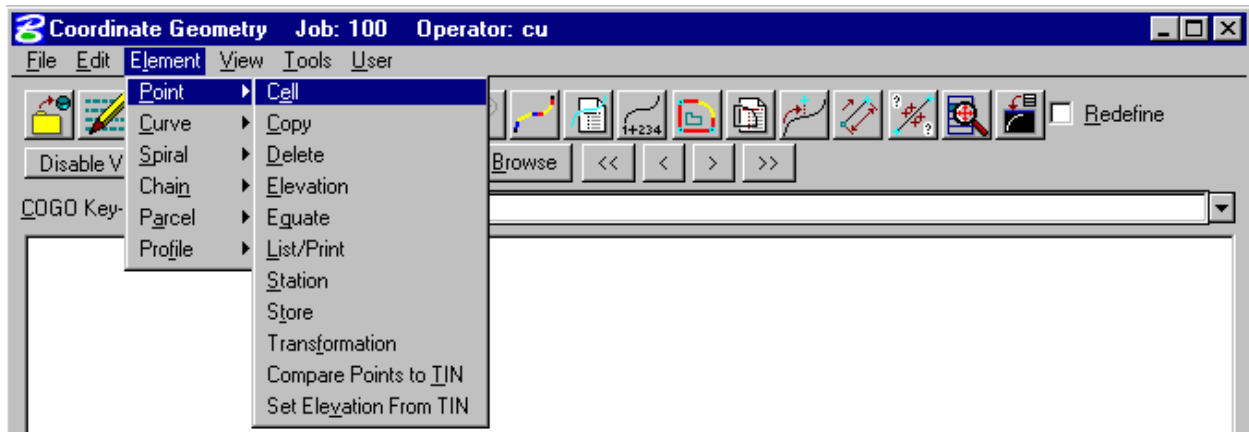
Read - the lines in the output buffer are processed. This may be done for the entire file (**All**) or by specifying a range of line numbers (**Line Range**).

Type - displays the content of the current input file, (**All**) or a portion of the file by specifying a range of line numbers (**Line Range**).

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5.4.3 Element Commands

5.4.3.1 ELEMENT>>POINT



Cell - assigns a cell name to a previously stored point

Copy – copies points or a point range to a new point number or range within the same Geopak database

Delete - allows you to input a point number (or range of numbers) to be deleted from the database.

Elevation - assigns an elevation to a previously stored point

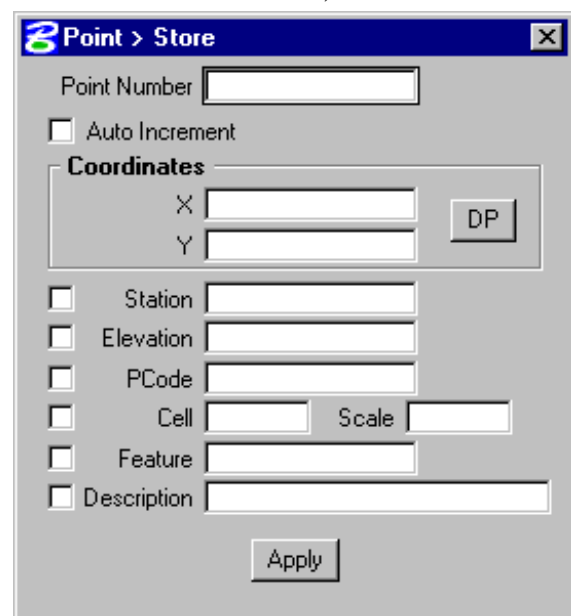
Equate - stores a new point with the same values as a previously defined point

List/Print - input a range of point numbers; **List** displays only the point numbers currently stored in the .gpk file. **Print** displays point number, x, y, z coordinates, station value and other information in the output buffer for the requested points. If visualization is on, this will cause the points to be displayed.

Station - allows you to specify a station for an existing point.

Store - stores a point located by key-in or by digitizing a point on the screen. A station, elevation, point code, cell, feature, or description can be added to the point.

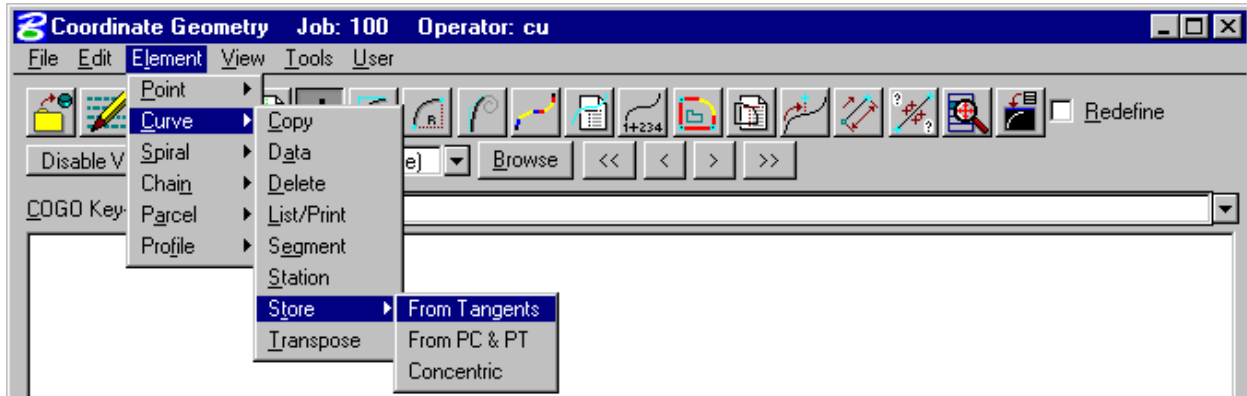
Transformation - transform one set of points into a new coordinate system.



Compare Points to TIN – computes the elevations of a given set of points based on a given DTM, and outputs the elevations to a text file.

Set Elevation From Tin – computes the elevations of a given set of points based on a given DTM, and stores the elevations to the points.

5.4.3.2 ELEMENT>>CURVE



Copy - copy a specified curve to another curve name

Data - calculates the geometric parameters of a curve, displaying values for Delta, Degree, Tangent, Length and Radius

Delete - will delete selected curve from the .gpk database

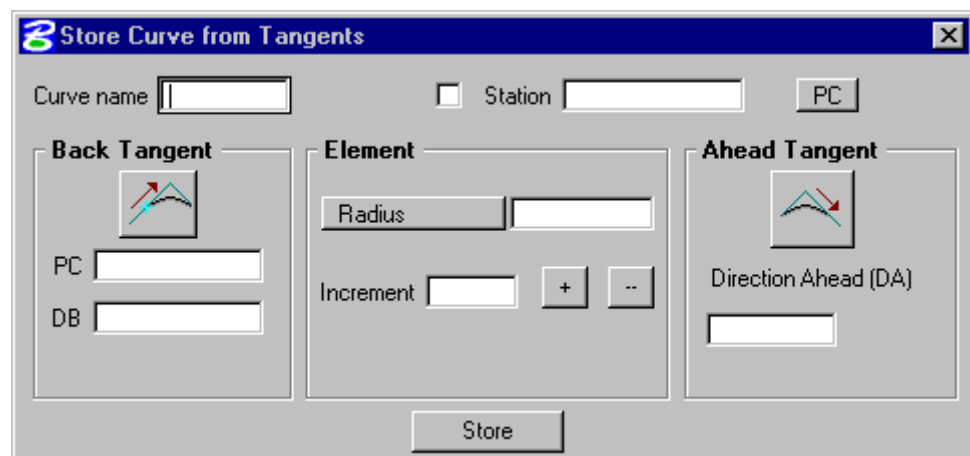
List/Print - will display all curve data for the selected curve. **List** displays only the curve names currently stored in the .gpk file. **Print** displays the curve data of the selected curve. Also if visualization is on this will cause the curves to be displayed.

Segment – defines new curves by dividing a stored curve into segments.

Station - allows the user to identify a curve and the position on the curve (PC, PI, or PT) that a station value may be assigned.

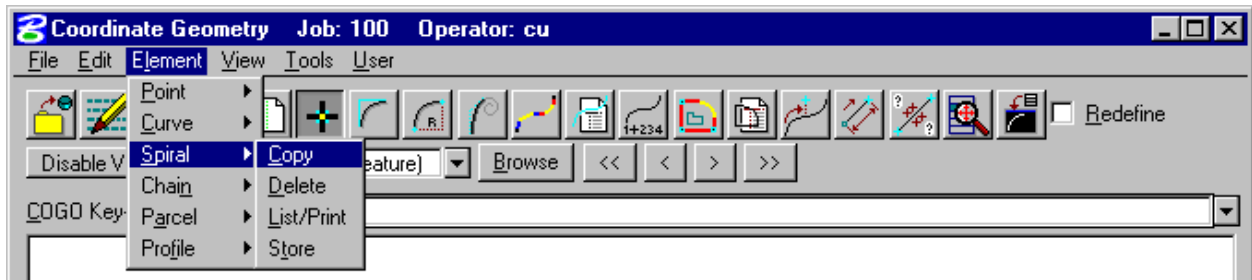
Store - provides various options for defining and storing lines and curves such as **Store Curve from Tangents** as shown to the right.

Transpose – reverses the curve direction.



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5.4.3.3 ELEMENT>>SPIRAL

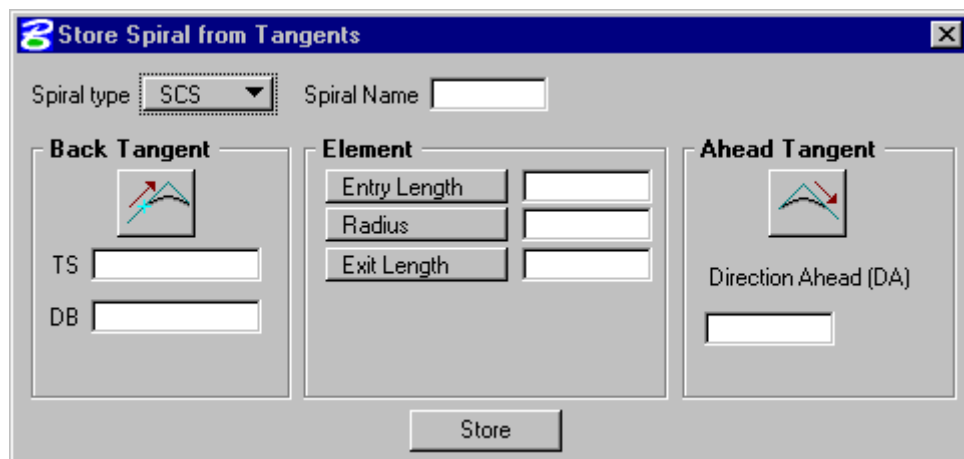


Copy - copy a specified spiral to another spiral name

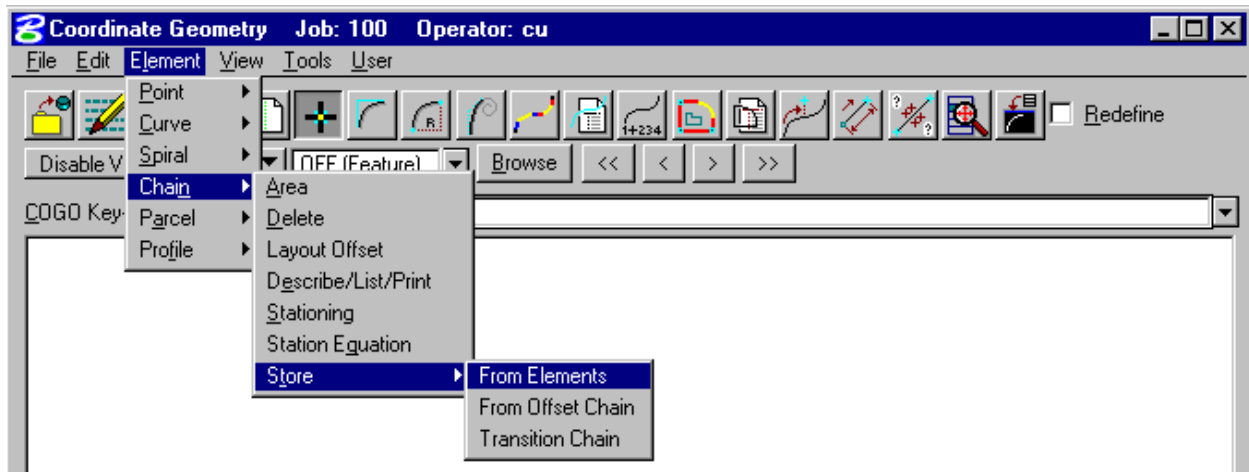
Delete - will delete selected spiral from the .gpk database

List/Print - will display all spiral data for the selected curve. **List** displays only the spiral names currently stored in the .gpk file. **Print** displays the spiral data of the selected spiral. Also if visualization is on this will cause the spirals to be displayed.

Store - provides various options for defining and storing spirals.



5.4.3.4 ELEMENT>>CHAIN



Area – calculates the area of a closed chain

Delete - deletes selected chains from **.gpk** database

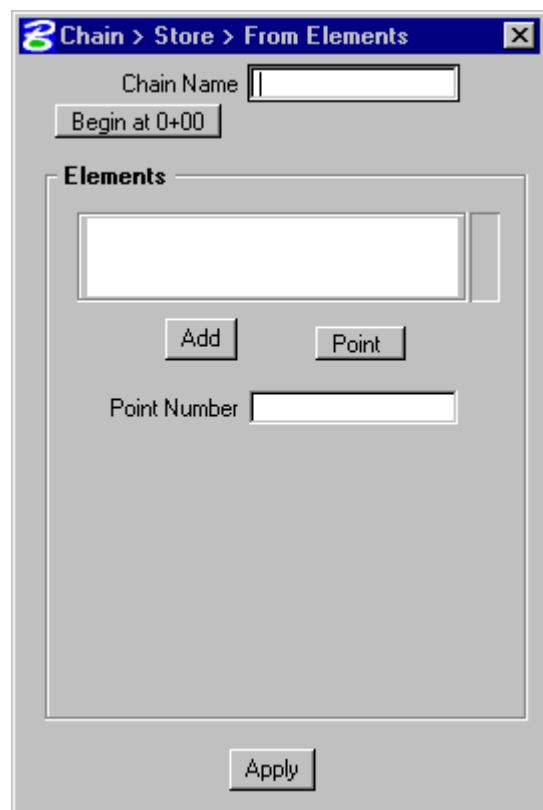
Layout Offset – computes the station and offset of a point or a chain based on a given chain.

Describe/List/Print – displays chain information. **Print** displays the name of each chain element. **Describe** displays the alignment data of each element in the selected chain.

Stationing - provides a method for stationing or re-stationing a chain.

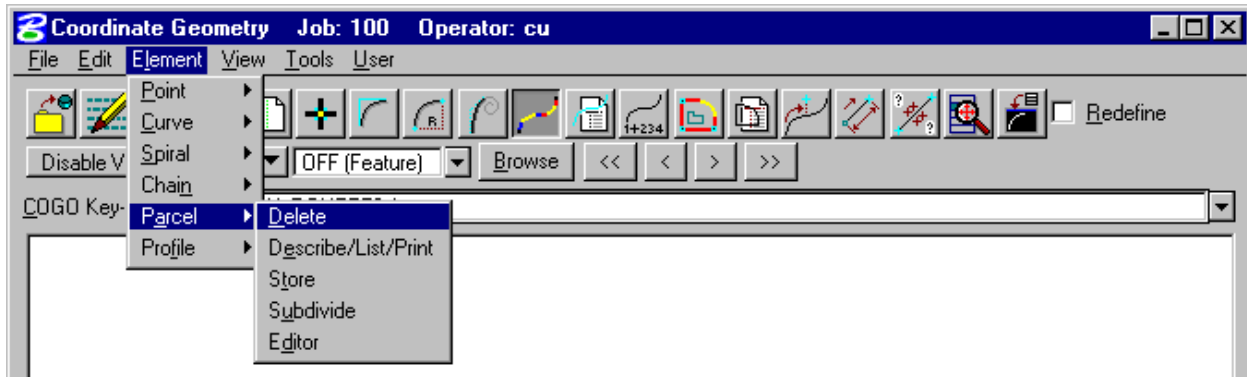
Station Equation - provides a method for applying a station equation to a chain

Store - provides three options for storing a chain in the database, **From Elements**, **From Offset Chain**, and **Transition Chain**.



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5.4.3.5 ELEMENT>>PARCEL



Delete - deletes selected parcels from .gpk database

Describe/List/Print - displays parcel information. **Describe** displays the elements of composition, the area of tract stored, taken and remaining and a point, bearing, distance description of the specified tract. **Print** displays the elements of composition, the area of tract stored, taken and remaining.

Store - allows a user to store a parcel by adding points, curves and spirals.

Subdivide – divides a parcel into individual lots.

Editor – edits a parcel

Manual Entry - Parcel Commands

Store Taken - allows you to store the portion of a parcel taken by entering point and curve names in either a clockwise or counterclockwise direction.

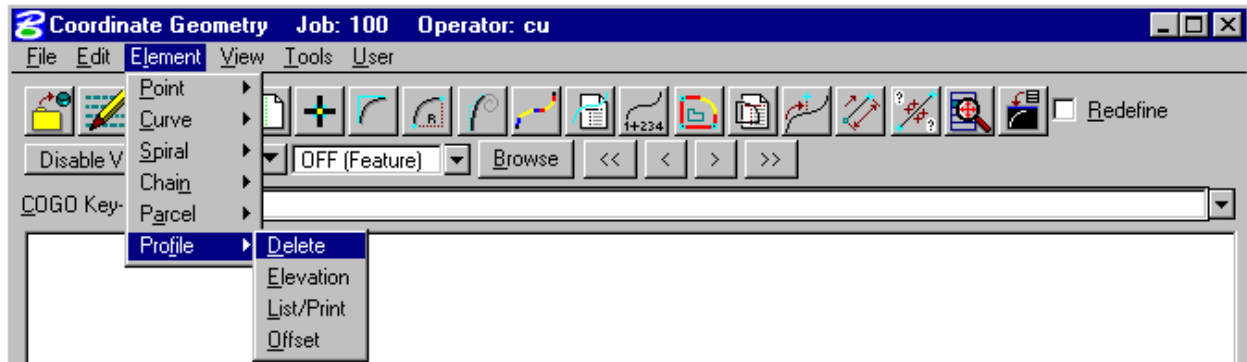
Store Easement - allows you to store an easement by entering point and curve names in either a clockwise or counterclockwise direction.

Own Parcel - stores the name of the owner associated with a previously stored parcel.

Make Legal - creates a legal description and writes it to a user named text file.

For more detailed parcel information, the *Geopak Manual* or the online help.

5.4.3.6 ELEMENTS>>PROFILES



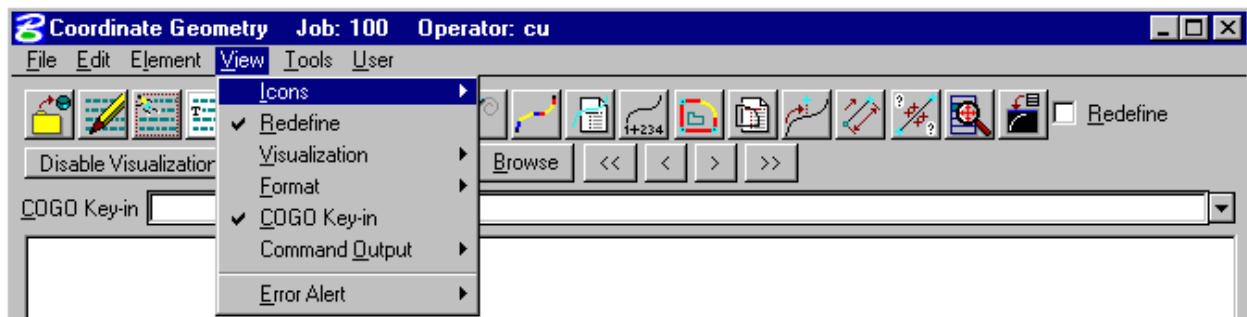
Delete - deletes selected profiles from **.gpk** database

Elevation - provides three options for reporting elevations along a selected profile, **Station**, **Even Station**, **Incremental Stations**

List/Print – displays profile information. **Print** displays the data of the selected profile from the **.gpk** database

Offset – stores a new profile at a given vertical offset.

5.4.4 View Commands



Icons – allows the user to customize which icons appear in the tool bar.

Redefine – shows the **Redefine** box on the tool bar.

Visualization – shows the visualization items on the tool bar.

Format – shows the format items (i.e. number of decimals, station format, etc.) on the tool bar.

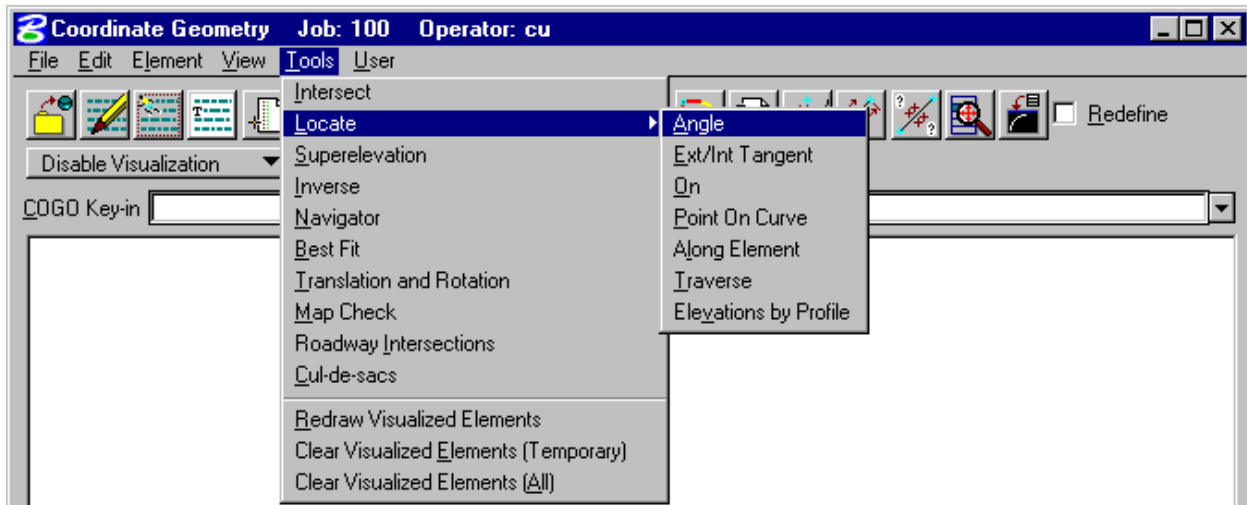
COGO Key-in – shows the COGO Key-in box for entering commands in the dialog.

Command Output - show the Command Output Window in the dialog box, and controls options for the Command Output Window.

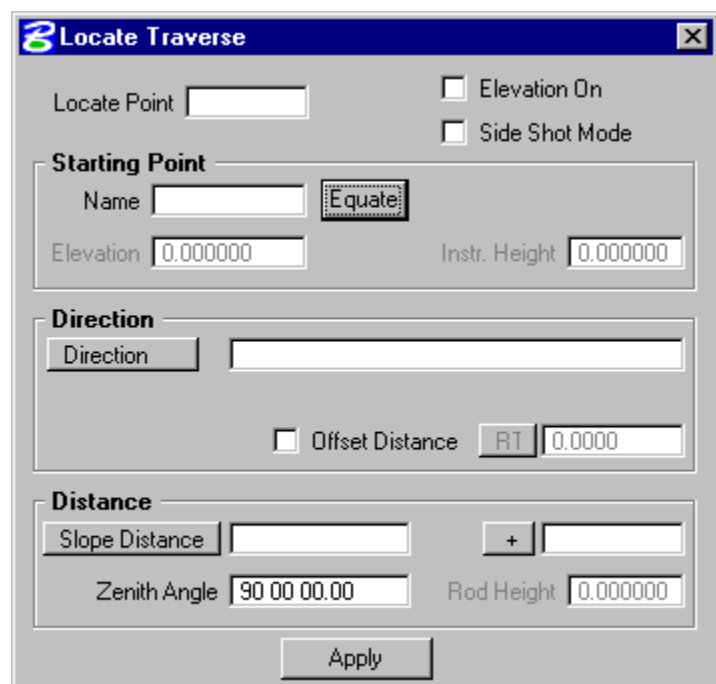
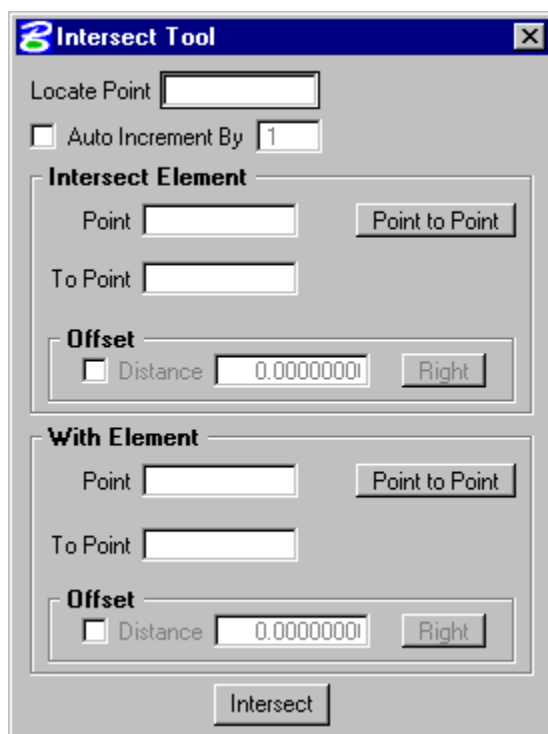
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Error Alert – allows the user to turn on a *beep* and/or bring up the COGO dialog when an error occurs.

5.4.5 Tools Commands



Intersect – stores a point at the intersection of the defined elements



Locate – locates a point from another point by several methods such as distance and direction, or station and offset. (To locate by distance and bearing, use the Tools >> Locate >> Traverse)

Superelevation – calculates the superelevation for a given chain. (This will be covered in more detail in Chapter 11)

Inverse – calculates the distance and direction between points.

Navigator – starts the COGO Navigator. (This will be covered in more detail in Section 5.5)

Best Fit – calculates a best-fit chain through a set of points.

Translation and Rotation – moves, rotates, and scales a data set.

Map Check – edits a parcel.

Roadway Intersection – calculates the data for the intersection of two roadways.

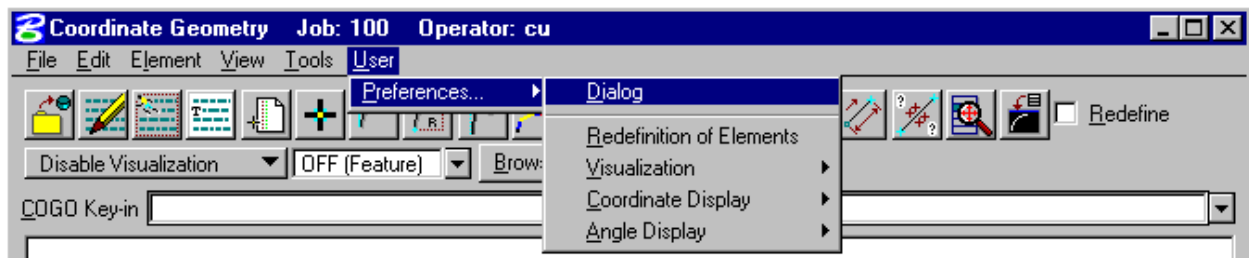
Cul-de-sacs – calculates the data for a cul-de-sac.

Redraw Visualized Elements – re-syncs the coordinate geometry data with the data displayed in the Microstation file.

Clear Visualized Elements (Temporary) – clears the temporary visualized elements from the view.

Clear Visualized Elements (All) – clears the visualized elements from the Microstation file.

5.4.6 User Preferences



Dialog - allows access to COGO Preferences dialog box.

Redefinition of Elements – toggles the **Redefine** option on/off. If **Redefine** is on, COGO data can be redefined/overwritten. (It is recommended to work with **Redefine** off so the user does not overwrite another user's data.)

Visualization – allows the elements to be displayed in the Microstation file permanently or temporarily.

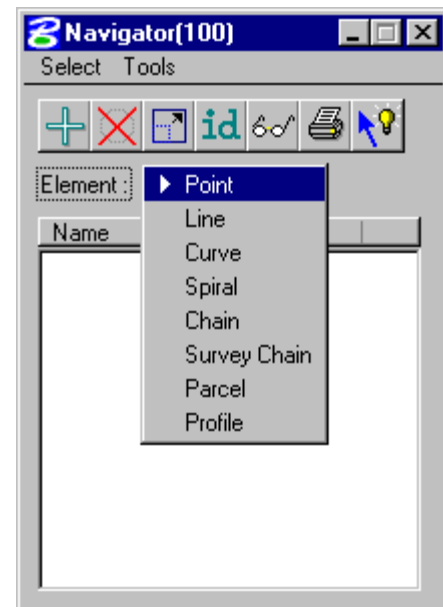
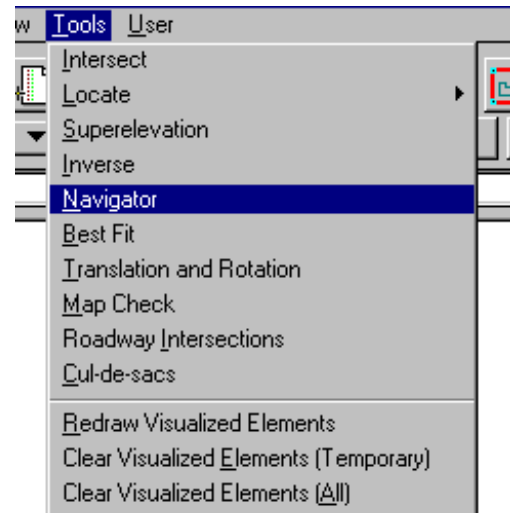
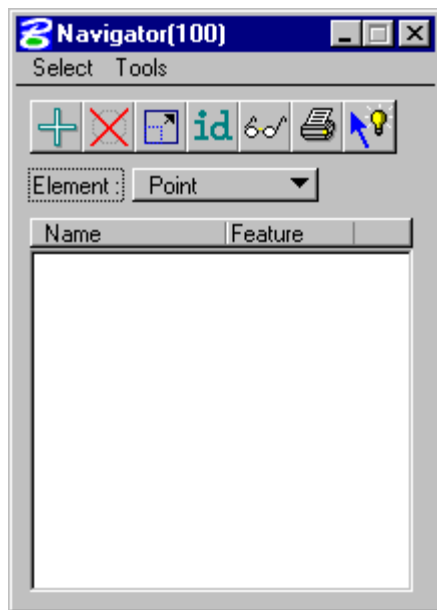
Coordinate Display – toggles between displaying NE or XY coordinates.

Angle Display – toggles between displaying Bearing or Azimuth.

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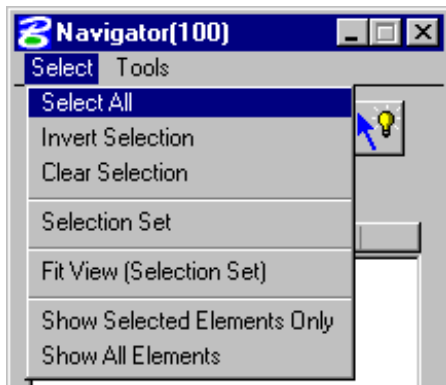
5.5 COGO Navigator

COGO Navigator is a tool to easily view and edit COGO data. **Navigator** can be accessed by the pull down menu **COGO >> Tools >> Navigator** or by the **Navigator** icon. The following dialog box will appear.



From the **Navigator**, points, curves, spirals, chains, survey chains, parcels, and profiles can be added, deleted, modified, identified, visualized, printed, or selected.

5.5.1.1 NAVIGATOR>>SELECT



Select All – selects all data items of a certain type. (I.e. all points)

Invert Selection – selects all items not previously selected, and unselects all items previously selected.

Clear Selection – unselects all items.

Selection Set - allows the user to create a selection set that meets particular criteria. This is the same as using the **Selection Set** icon.

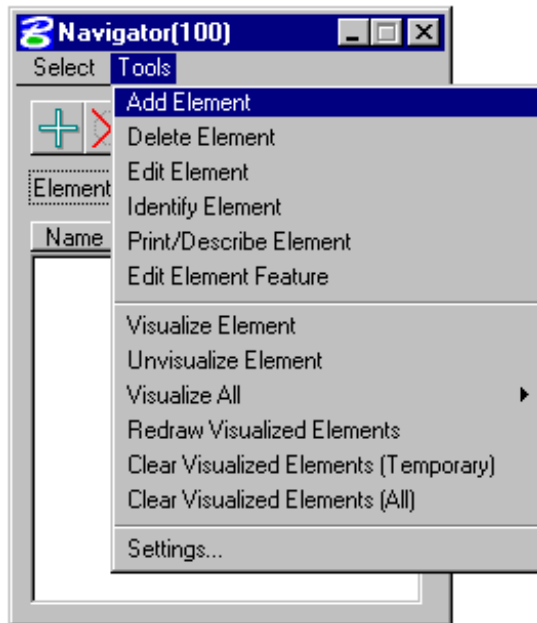


Fit View (Selection Set) – fits the items selected to the active Microstation window.

Show Selected Elements Only – only the items in the selection set will be displayed in the Microstation window.

Show All Elements – all items in the database will be displayed in the Microstation window.

5.5.1.2 NAVIGATOR>>TOOLS



Add Element – allows the selected type of element to be stored.



Delete Element – deletes the selected type of element.



Edit Element – allows the selected element to be edited.



Identify Element – allows the user to select an element by selecting it graphically.



Print/Describe Element – displays the selected element's coordinate or alignment data.

Edit Element Feature – Changes the feature code of the element.



Visualize Element – displays the selected elements according to their feature codes.

Unvisualize Element – un-displays the selected elements.

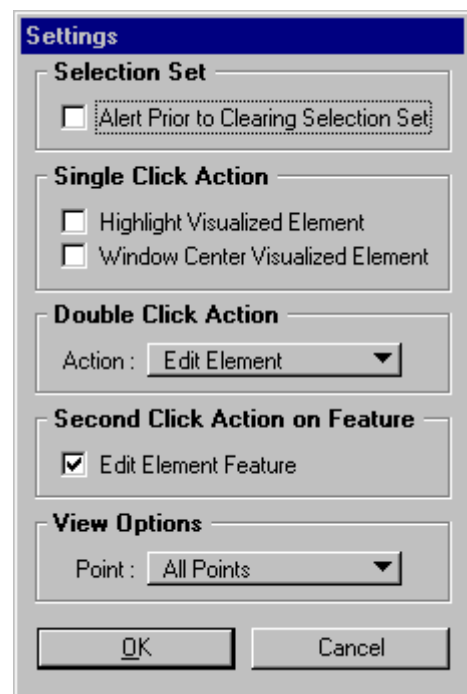
Visualize All – displays all of the elements of a certain type, or all elements.

Redraw Visualized Elements - re-syncs the coordinate geometry data with the data displayed in the Microstation file.

Clear Visualized Elements (Temporary) – clears the temporary visualized elements from the view.

Clear Visualized Elements (All) – clears the visualized elements from the Microstation file.

Settings – allows the user to define certain actions and behaviors of the Navigator.



5.6 Importing CEAL Data

A CEAL interface file can be imported using the following command:

LOAD CEAL FILE *filename*

where *filename* is the name of the CEAL interface file. This command will create a Geopak input file that can be saved or read. Points, curves, spirals, chains, and alignment profiles can be transferred to Geopak from CEAL. Once the above command has been executed, to store the data into the .gpk file the input file must be read by going to **Edit>>Read All**.

5.7 Additional Information

Additional COGO commands and information can be found in the *Geopak Manual*.